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EFFECT OF PERMANENT MAGNETIC POLE ORIENTATION ON FIELD STRENGTH IN VISCOELASTIC MAGNETIC ABRASIVE FINISHING PROCESS

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ABSTRACT

Viscoelastic magnetic Abrasive Finishing is a new method which has evolved from traditional MAF process where an abrasive- Ferromagnetic laden media is used which provides an effective machining option. In this process,, along with an abrasive particles in presence of a viscoelastic medium is used to provide better surface finish as viscoelastic medium increases the bonding of ferromagnet particles with abrasive particles. In the present paper Ansys Maxwell 16.0is used to obtained the distribution of Fan shaped magnetics by using Magnetic field on the workpiece through which the effective surface of machining can be predicted. The pattern is obtained using combination of 4 magnetic poles taken 2,3 and 1 at a time by arranging them at different angles. After observing the pattern, it was found that the most effective machining would be done by taking 4 poles surrounding the workpiece as it would cover the entire surface of the workpiece and the combination of 3 magnet at an angle of 120 degree is effective when 3 poles are taken at a time. 90-degreeangle between the pole must be taken when we are using two poles as the magnetic field intensity is maximum in this combination.

KEYWORDS: MAF, Viscoelastic, Magnetic Abrasive Finishing & Magnetic Field

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Original Article

INTRODUCTION

Magnetic abrasive finishing is an effective machining process in which magnetic field is used to machine the target surfaces of the workpiece by influencing the carbonyl particles and directing them towards the wall of the workpiece for machining. In conventional abrasive machining process both the workpiece and the target surface are polarized and due to the interplay of magnetic field, a Brush of abrasive is formed which results in the effective machining of the workpiece. This effective concept of machining got the eyeball of many scholar and initiated a large number of researches in this field like Kang and Yamaguchi [1] developed a multi pole dip- system for the machining of internal surface of the capillary tube. The researchers highlighted the difficulties faced in machining of the capillary tube mainly in controlling the magnetics abrasive in MAF process. The researchers suggested that the multi pole system with alternate magnetic and nonmagnetic region simultaneously applied on the work piece which resulted in the effective machining of the long capillary tube. This process has allowed the application of MAF on long Capillary tube which was earlier confined to the short length tube only. The final conclusion of the researcher was that, the double pole system finishes the work piece in half the time as compare to the single pole system. V. K Jain [2] explained various non-traditional machining process which are used in modern times that involves the use of abrasive and the media to support it. The various process which he has discussed in his paper were Abrasive Flow Finishing (AFF), Magnetic Abrasive Finishing (MAF), Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Elastic Emission Machining (EEM) and Magnetic Float Polishing.

He laid attention on the magnetic abrasive finishing process and gave some important conclusion like involvement of slot in the magnet over non machining zone and the use of pulse Dc supply rather than smooth DC supply in the system. Wani et al.[4] gave stress on Magnetic Abrasive flow finishing which is a process made by combining the advantage of both abrasive flow machining and the magnetic abrasive finishing process, and used finite element method to find distribution of magnetic potential in the magnetic brush. Through this distribution the researcher evaluated machining pressure, surface finishing and material removal. After the successful evaluation of the results there searcher claims that these results are similar to those present in the literature. Kala et al. [4] developed a set-up which aims to catch the force signature for double disc magnetic abrasive finishing process and the conventional abrasive magnetic abrasive finishing process. By these properties the researchers aims to understand the working of the flexible magnetic abrasive brush. Thus, to do this, the researchers performed the magnetic abrasive finishing operation in single as well as double disc and finally understood the property of flexible magnetic abrasive brush behavior from it. Wu et al [5] developed a model of magnetic abrasive finishing process and analyzed its properties based on the rotational speed, cutting fluid and the magnetic pole and current frequency and its effect on change in material removal and surface finish. The researchers finally claimed that neat cutting oil is required for processing which results in higher material removal and finer finish. They also concluded that finishing is better with the increasing in rotational speed and as the current frequency increases the angle variation of the particle increases and if frequency is low the surface requirement is up to few nanometers. Ratho det al. [6] correlated the difference shape factor with wide range of particle size. The researcher made use of slurry abrasion tester with silica sand slurry and commented on the effect of sliding distance slurry abrasion volume, where they argued that the volume loss is proportional to the sliding distance. They also studied the effect of micro ploughing and cutting. Srivastav et al. [7] simulated a model of electrochemical magnetic abrasive finishing process in which the researchers used stainless steel workpiece whose radius was ten mm and thickness was 2.5mm. the researchers used chromium oxide as the abrasive particle whose average diameter was 387 micrometers. The intensity of magnetic field was around 1 tesla and the rotational speed of tool was taken as 5835 rpm and its diameter was 6 mm. The electrolyte used for the experiment was brine solution with twenty percent concentration. The researchers study the thermal model in both steady and transient model. Srivastavand Amit [8] did the thermal analysis of work- brush interface and along the work piece depth in magnetitic abrasive finishing process with the help of Ansys R15 software in both steady and thermal state. The value of magnetic field intensity given to 6 mm diameter tool was 1 tesla. The researcher used chromium oxide abrasives of about 387 micrometer, Diameter. The work piece has a radius of 10 mm and 2.5 mm thickness and the material of the work piece was silicon nitride. Singh et al.[9] used Taguachi Lorthogonal array to design an experiment which could measure surface temperature of the finishing surface of mild steel using MAF process. The researchers used current, working gap, Rotational speed and abrasive weight as its important process parameters. After the Taguachi optimization the Fuzzy logics used by researcher through which prediction of surface temperature is and also it is validated. Jaiswal et al. [10] made FEM model of MAF and investigated the distribution of magnetic force on the workpiece. The researcher also made a theoretical model for computing the material removal and surface roughness. For this the workpiece was considered with uniform surface, without statically distribution. Numerical experiments were also computed which were validated later on through literature. Yanet all [11] performed the experiment on MA genetic abrasive finishing based on a simulated model made by FEM model electromagnetic inductor. He then compared the simulated model with the actual electromagnetic inductor and predicted a marginal error of only 7 percent. Li et all [12] developed a finishing set up having new media for finishing the rotatory surface ANSYS Maxwell was used to determine the optimum angle between the poles and the mathematical

model was made to compute the MRR in which pressure and velocity based on arced wear model. A MRR computation model was made which predicted MRR as a function of pole rotational speed, Magnetic flux density, cam rotational speed and the ferromagnetic and abrasive particles' diameter. Li et all [13] proposed a new viscoelastic magnetic Abrasive based on analysis of field characteristic and existing finishing process. They also discussed the motion locus of the abrasives. The present scenario, abrasive flowing finishing, grinding, abrasive brush deburring, magnetorheological finishing, manual deburring etc. These are broad name in term of finishing but still they possess some limitations in finishing quality and efficiency. Shimamura et al. [14], [15] modelled and tested that magnetic abrasive particles are subjected to the pressure for machining and that pressure is a function of magnetic flux density. In a number of abrasive particles and the permeability of abrasive medium. Fox et al [16] observed that the magnetic force (function of the volume and magnetic susceptibility of the ferrous particles in the magnetic field, magnetic field intensity and the gradients at the finishing area). Srinivas et al. [17] studied the distribution of the magnetic field intensity along with the computation of torque and force and related flow parameters of Viscoelastic magnetic Abrasive finishing process with magnetic field intensity. The Researchers used Ansys Maxwell and Ansys Fluent in order to find co relation between the flow parameters and magnetic field intensity and commented on the successful application of the proposed viscoelastic media. The researchers also plotted the graph between the magnetic field intensity and the current which is applied on the single pole electromagnet to produce the desired magnetic field for machining in the magnetic abrasive finishing process. Srinivas and Anant [18] studied the pressure variation in abrasive flow machining process with the help of a simulated model made on Ansys Fluent and commented on the effect of pressure variation in the machining operation. They used viscous media similar to that used in viscoelastic magnetic abrasive finishing with the difference that in later process there is an addition of carbonyl particles which gets activated by magnetic field. The researcher computed pressure difference between 40 MPa and 20 MPa and the value of pressure so obtained which was validated with the help of literature review. Ali et al. [19] reviewed various researches on AFM which uses a viscoelastic media and semi solid media which can support various abrasive based finishing process including both magnetic and non-magnetic based finishing process. Bhardwaj et al [20] compiled the researches which contained the use of viscoelastic media in various hybrids of abrasive flow machining process, and the researchers also commented on the tooling and fixturing in various hybrids of AFM and the compatibility of the viscoelastic media with the hybrid process. So, it can be seen that Viscoelastic Magnetic Abrasive Finishing has a vital role in Finishing department and must be consider for effective machining operations.

MODELLING AND ANALYSIS

The aim of the paper is to explore the appropriate arrangement of magnetic poles to obtain the maximum finishing of the work piece using viscoelastic magnetic abrasive finishing process. For which a setup was proposed which contain a hollow work piece whose internal surface was machined by the viscoelastic fluid which is made to reciprocate between the work piece by providing the pressure difference in presence of magnetic field produced by Fan shaped magnet with specific centre angle which are acting like the magnetic poles. The result of such a combination of the two would produce an effective machining.

The viscoelastic media so produced consist of ferromagnetic particles around which the 4 abrasive particles are kept. Alumina is the material of abrasive particle and the ferromagnetic particle is iron. The work piece is taken for aluminium and the magnetic poles are made of copper. Initially CREO 3.0 is used for making initial model which was later imported to Ansys Maxwell for analysis. The Shape of the mess element was Hexagonal and the total number of elements

were 3 X10^{-3}. Although after several trial it was concluded that the result obtained is independent of the mess size. The material used for analysis had the following properties which is described in the table 1. consisting of fluid and solid properties of materials used in simulations. Aluminium is taken for the work piece and NdFe35 is taken for the magnet which is acting as a pole for the setup. Various model is made in which 2 poles having 60- degree centre angle are arranged at an angle of 90,180-degree, single pole and Also model with 3 poles kept at 120 degree is also analysed to check the reach of the magnetic field on to the surface. Then similar thing is done with 90-degree centre angle shaped magnet. The results so obtained while performing the Maxwell simulations are discussed in the subsequent section.

Table 1: Showing Properties of Material in Simulation

Material	Type	Density (Kg/M^3)	Viscosity (Kg/ M-S)	Thermal Conductivity (W/ M-K)	Specific Heat (J/Kg-K)	Relative Permeability
Viscous Fluid	Fluid	1219	0.789	0.22	20.25	1.00000004
Aluminium	Solid	2719		202.4	871	1.000021
Iron Particle	Solid			16.27	502.48	4000
Alumina abrasives	Solid	3950	Alumina abrasives	12	451	1
Nd Fe 35	solid					0.99

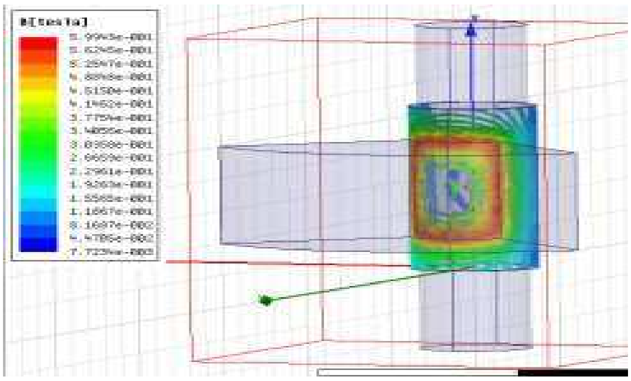

Figure 1: 90 Degrees Centre Angle Single Pole 90 Degree Apart to Each Other's

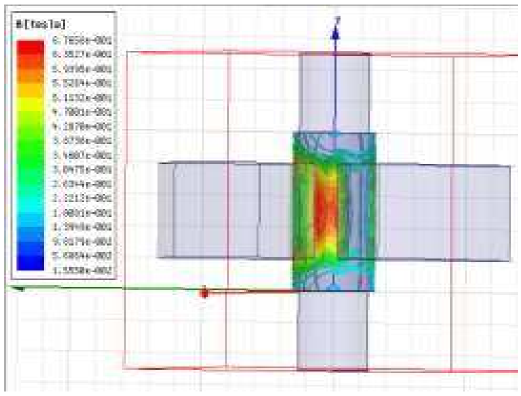

Figure 2: 90 Degrees Centre Angle Double Pole

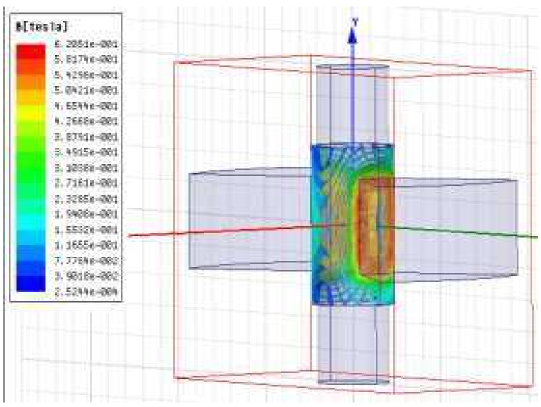

Figure 3: 90 Degrees Centre Angle Double Pole 120 Degree Apart

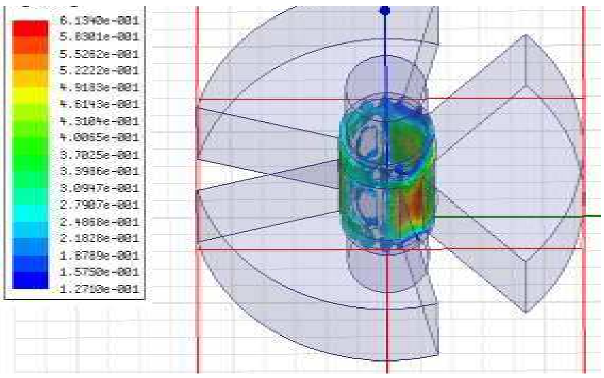

Figure 4: 90 Degrees Centre Angle 3 Pole 180 Degree Apart

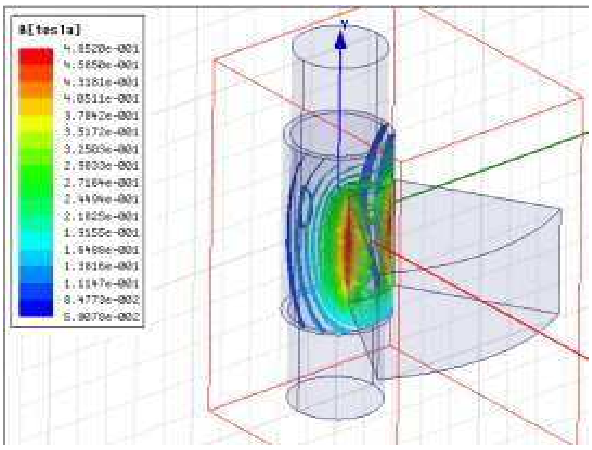

Figure 5: 60 Degrees Centre Angle 1 Pole Degrees Apart

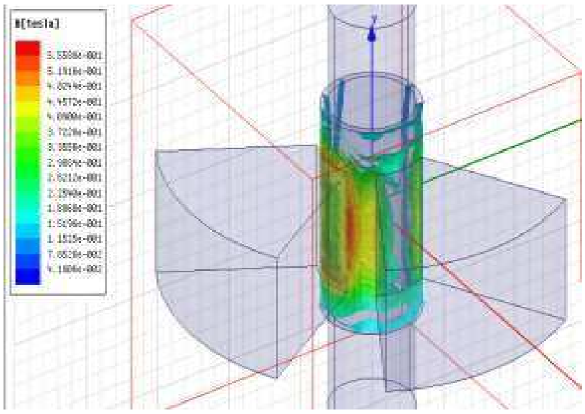

Figure 6: 60 Degrees Centre Angle 2 Pole

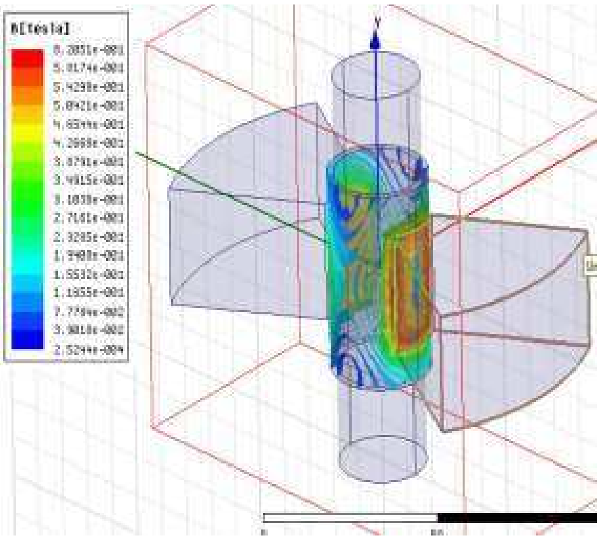

Figure 7: 60 Degrees Centre Angle 2 Pole 180 Degrees

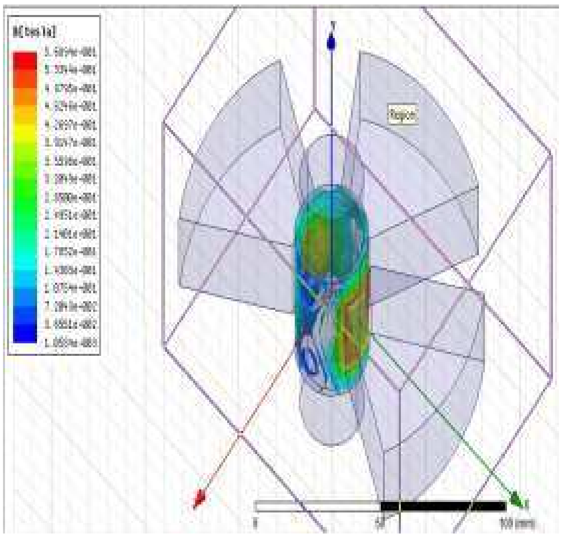

Figure 8: 60 Degrees Centre Angle 3 Pole

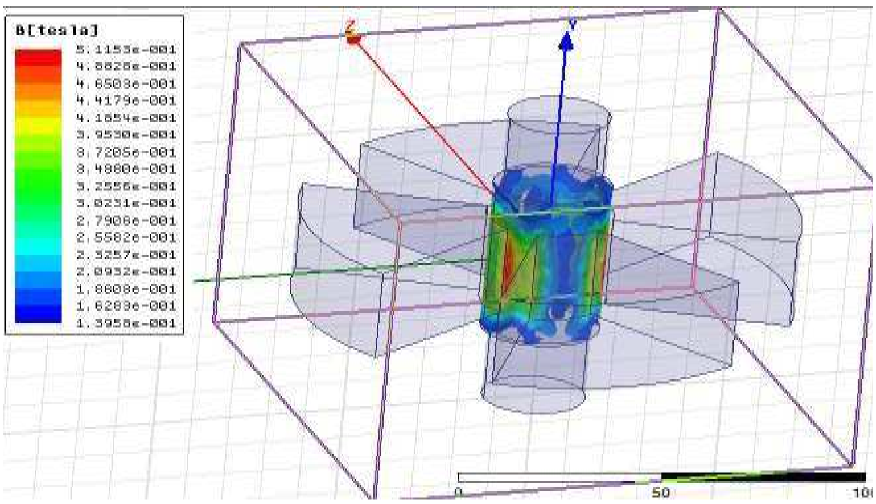

Figure 9: 60 Degrees Centre Angle 4 Pole 90 Degree Apart

RESULTS AND DISCUSSIONS

The simulation were performed using fan shaped magnets to determine the effects of the angle between the pole and the finishing and also the number of poles. Two magnets were taken with centre angle 60 and 90 having inner diameter of magnetic pole as 32 mm and the outer diameter of magenetic pole as 126 mm. The material of the magnet was taken as Ndfe35 while the workpiece is aluminum. For figure 1 the force on abrasives is 0.00012427 N and that on iron particle is 0.15769 N and the maximum value of magnetic field is 0.5594T. For figure 2 Force on abrasives is0.02212427 N and that on iron particle is 0.17769 N and the maximum value of magnetic field is 0.6794 T. for Figure 3 the Force on abrasives is 0.22427 N and that on iron particle is 0.18769 N and the maximum value of magnetic field is 0.6205T. For figure 4 the force on the abrasives is 0.00021954 N and the force on the iron particle is 0.074456 N and the maximum value of magnetic field is0.613 T. For figure 5 Force on abrasives particle is 6.8758 X10^{-5} and that on iron particle is 0.075299 N. The maximum value of magnetic field came out to be 0.4852 T. For figure 6 the Total force on the abrasive is 8.3673 X 10^{-5} N and the force on the iron particle is 0.00046695 N. While the maximum value of the magnetic field came out to be 0.6558 T. For figure 7 the Force on the abrasive particle 0.0009361 N and the force on iron particle is 0.018211 N while the maximum value of magnetic field came out to be 0.6205 T. For figure 8 the total force on the abrasives is 0.00019519 N and the maximum value magnetic field came out to be 0.56 Tesla. The total force on abrasive particle is 0.0011053 N and the force on the iron particle is 0.0011317 N. The maximum value of magnetic field intensity is 0.5115 T. it can be noticed that the entire area of the workpiece is covered when we use 4 poles with centre angle 60 degree and horizontal axis of fan shaped magnet aligned at an angle of 90 from each- other.

CONCLUSIONS

Following points can be concluded:

- As the value of the angle θ goes up, the value of magnetic -force (which is proportional to magnetic flux density) goes down due to reduction in magnetic flux density which minimizes the finishing effects.
- When angle between the poles is 90 degree, the magnetic field lines are closely packed and are densely located within the work piece. The finishing effect of the work piece would be more as the media would flow near to the workpiece due to the magnetic field effect.
- The finishing effect would precisely.
- Decrease when the poles are kept 180 degrees apart when compare to that of 90 degree as the media would be spread due to opposite magnetic - force of the poles at 180degree.
- Finally, after going through all the cases of both centre angles it can be concluded the angles between N pole and S pole is a critical factor influencing finishing effects and efficiency with certain media.
- 90° angle the best regarding the MRR because the magnetic flux density is the maximum. The results are in accordance to li et. all [7].

REFERENCES

1. *Kang, Junmo., Yamaguchi, Hitomi: Internal finishing of capillary tubes by magnetic abrasive finishing using a multiple pole-tip system, Precision Engineering 36 (2012) 510–516, 2012.*

2. *Jain, V. K: Magnetic field assisted abrasive based micro-/ nano-finishing, Journal of Materials Processing Technology 209 (2009) 6022–6038, 2009.*

3. *Wani, Amit. M., Yadava, Vinod., Khatri, Atul: Simulation for the prediction of surface roughness in magnetic abrasive flow finishing(MAFF), Journal of Materials Processing Technology 190(2007) 282–290.*

4. *Kala, Prateek., Pandey, Pulak. M., Verma, Girish. C., Sharma, Varun: Understanding flexible abrasive brush behavior for double disk magnetic abrasive finishing based on force signature, Journal of ManufacturingProcesses28 (2017) 442–448, 2017.*

5. *Wu Jinzhong., Zou, Yanhua., Sugiyama, Hitoshi: Study on finishing characteristics of magnetic abrasive finishing process using low-frequency alternating magnetic field, IntJAdvManufacturingTechnology85:585–594 DOI 10.1007/s00170–015–7962–9, (2016).*

6. *Rathod, Avishkar., Sapate, S. G., Khatirkar, R. K: Shape Factor Analysis of Abrasive Particles Used in Slurry Abrasion Testing, Internationa L Journal Of Mechanical And Industrial Engineering (Ijmie) Issn No. 2231 – 6477, Vol-2, Iss-4,2012.*

7. *Reddy, A. C. (2015). Studies on loading, cracking and clustering of particulates on the strength and stiffness of 7020/Si Cp metal matrix composites. International Journal of Metallurgical & Materials Science and Engineering, 5(1), 53–66.*

8. *Srivastava, Ankit.Kumar, komma. V. R: Finite Element Modelling of Electrochemical Magnetic Abrasive Finishing, Imperial Journal of InterdisciplinaryResearch (IJIR), Vol.2, Issue-12, 2016, ISSN: 2454–1362.*

9. *Srivastava, Ankit. Kumar., Katiyar. Amit.: Modelling and Simulation of Magnetic Abrasive Finishing for Thermal Analysis, Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-12, 2016 ISSN:2454–1362.*

10. *Sundaramurthy, A. (2017). Detection and Extraction of Brain Tumor from Magnetic Resonance (MR) Image: Review and Analysis. International Journal of Electrical and Electronics Engineering (IJEEE), 6(3), 1–8.*

11. *Singh, Rajneesh. Kumar., Singh, D. K., Gangwar. Swati.: Fuzzy logic optimization of process parameters affecting surface temperature in MAF, IOP Conf. Series: Materials Science and Engineering 404 (2018) 012017 doi:10.1088/1757-899X/404/1/012017.*

12. *Jaiswal, S. C., Jain, V. K., Dixit, P. M.: Modelling and simulation of magnetic abrasive finishing process, Int JAdv Manufacturing Technology (2005) 26: 477–490, DOI 10.1007/s00170-004–2180.*

13. *Yan, Q. S., Qiu, T. X., Gao, W. Q., Meng, L: Simulation and Experimental Analysis of Electromagnetic Inductor for Magnetic Abrasive Finishing, Key Engineering Materials Vols. 389–390 (2009) pp 193-198 Online:2008-09–26 © (2009) Trans Tech Publications, Switzerland, doi. 10.4028/ 390.193.*

14. *Li, Wenhui., Li Xiuhong., Yang, Shengqiang., Li, Weidong: A newly developed media for magenetic abrasive finishing process: Material removal behavior and finishing performance, Journal of Materials Processing Tech 260(2018) 20–29.*

15. *Li, Xiuhong., Li, Wenhui., Yang, Shengqiang.: Effect of coupling Agenton Interfecial Bonding Properties of Visecoelastic Magnetic Abrasive Tools and Finishing Performance, ISSN 1473-804 online, 1473-8031 print, DOI 10.5013/IJSSST.a.17.28.17.*

16. *Agboola, R. Analytical Interpretation of Geomagnetic Field anomaly along The Dip Equator.*

17. *ShinmuraT, TakazawaK, Hatano E. Matsunaga M. (1990) Study on magnetic abrasive finishing. Ann CIRP, 39(l):325–328.*

18. *ShinmuraT., TakazawaK., Hatano E. and Aizawa T. (1985) Study on magnetic abrasive process-process principles and finishing possibility, Bull. Japan Soc. Prec. Eng. 19(1) 54–55.*

19. *Kim JD., Choi MS. (1995) Simulation for the prediction of surface accuracy in magnetic abrasive machining. J Mater Process Tech53:630–642.*

20. *Srinivas. K., Murtaza. Q., Aggarwal. A. K.: Variation of Flow parameters and Magnetic Flux in Viscoelastic Magnetic Abrasive Finishing process, ISSN 0973–4562 Volume 14, Number 8, pp. 1940-1946, (2019).*

21. *Hassan, M. B., Hassan, A. F., & Obe is, A. S. Static Magnetic Field Influence on Pondero motive Self Focusing of Laser Beam Through Plasma.*

22. *Srinivas. K., Bhardwaj, Anant.: Pressure variation in Abrasive Flow machining: Modelling and simulation, 3rdinternational conferenceon advanced Production and Industrial Engineering (ICAPIE'18), Paper ID ICAPIE-2018-PE MT 218.*

23. *Ali, Parvesh., Ranganath, M. S., Walia, R. S., Murtaza, Q: Various developments in abrasive flow machining process: A Review, 3rdinternational conference on Advanced Production and Industrial Engineering (ICAPIE'18), Paper Id Icapie-2018-PE MT215.*

24. *Bhardwaj, Anant., Ali, Parvesh., Walia. R. S., Murtaza, Qasim., Pandey, S. M.: Development of Hybrid Forms of Abrasive Flow Machining Process: A Review, Advances in Industrial and Production Engineering pp 41–67, Part of the Lecture Notes in Mechanical Engineering book series (LNME), conference paper (2019).*

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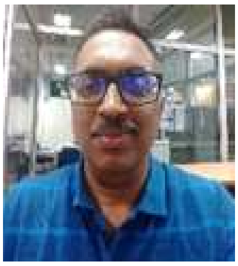

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